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CHANGES OF SOURCE AREAS AS REFLECTED BY THE DEPRESSION OF THE KÖRÖS RIVERS'

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INTRODUCTION

Since the new phase of geological mapping in the Great Hungarian Plain, i. e. since 1964, boreholes of about 1200—1500 m depth were drilled by the Hungarian State Geological Institute, nearly parallel with the Tisza-bed in N-S direction, as well as in E-W direction also parallel with Körös River, East of the Tisza. These boreholes discovered the major of Pliocene formations in the Great Plain, and the complete section of the Quaternary formations.

The boreholes aimed to provide the more particular knowledge of the geolcgical and hydrgoeological features of the subsidence-filling sediments, already after the sedimentological, paleontological as well as paleomagnetic investigations carried out in the last years.

In the eastern part of the W-E profile a new borehole was drilled in 1976—77 down to the depth of 1137 m, i. e. the borehole Dv..No. 1 at Dévaványa-Kéthalom.

This village is situated some km North of Dévaványa. The point of borehole lies North of the Recent Hármas-Körös. The Rivers Fehér Körös, Fekete Körös, Sebes Körös and Berettyó join each other east of the point, thus the borehole was situated in the axis of the alluvial fan of the Körös discovering its sedimentary sequence *(Fig. 1)*.

The sedimentolcgical, paleontological and paleomagnetic investigations of the borehole profile of Dévaványa showed that the Late Pliocene and Quaternary formations were penetrated [FRANYÓ, F., 1977; RÓNAI, A., 1978, 1979; RÓNAI, A., SZEMETHY, A., 1979]. In Hungary the Pliocene formations are divided into two major units, i. e. the Upper and Lower Pannonian. Each of them are usually subdivided into three members [JÁMBOR, Á., KORPÁS—HÓDI, M., 1971; BARTHA, F., 1975]. Accordingly, the Dévaványa profile discovered the upper part of the Upper Pannonian sequence.

On the basis of paleontolcgical and paleomagnetic investigations, in the profile, the Pliocene-Pleistocene boundary denoting approximately 2.4 million years, lies in a depth of 420 m. Starting from the rate of deposition within the Pleistocene, the GAUSS—GILBERT-boundary (i. e. 3.4 million years) lies in 620 m, while the 5 million years in about 920 m, as to the preliminary estimations [RÓNAI, A., SZEMETHY, A., 1979]. This, however, contradicts to the new concept, i. e. the lower boundary of the Pliocene can be marked at 5 million years.

Within the Pleistocene the Olduvan begins in 320 m (1.8 million years), while the BRUNHES—MATUYAMA-boundary lies in 120 m (0.7 million years) [RÓNAI, A., SZEMETHY, A., 1979; RÓNAI, A., COOKE, H. B. S., HALL, J. M., 1979]. In the profile freshwater lacustrine formations are found between 490 and 1137 m, while between 490 m and the surface fluviatile sediments can be observed [FRANYÓ, F., 1977].

Out of the manysided investigations governed and sponsored by the Hungarian State Geological Institute, in this paper, the results of micromineralogical analyses will be dealt with. These analyses aimed to mark the boundaries between major changes within the sequence, i. e. to dissect the sequence also in this manner. Further, the characteristics of the source areas had to be determined, as well as having micromineralogically characterized the whole profile to search for connections with the known formations of the surrounding areas.

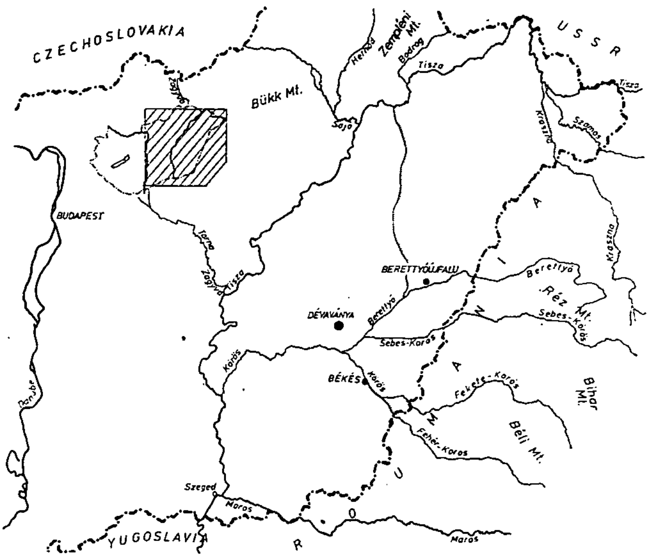

Fig. 1. Location of the borehole.

It is well-known from the previous investigations carried out in the Great Plain that the change in the grain size distribution highly affects the composition of heavy minerals. Even in case of the same source area considerable differences are found in the mineral composition of the coarser and finer-grained sediments [MOLNÁR, B., 1969]. E. g. in coarser-grained sediments the quantity of magnetite-ilmenite and garnet, in the finer-grained ones that of chlorite and micas are considerably increased.

Thus, in favour of realistic conclusions, the analysis of grain-size distribution of the chosen samples was also carried out *(Figs 2—3,* II*)*. The strata which contained the required fraction of 0.1—0.2 mm only in small percentage were not investigated from the heavy-mineral point of view. In each sample 300 grains were investigated and this was the basis to the percentual determination of the different mineral grains. Under certain critical review the results proved to be comparable and provided the possibility for the realistic evaluation.

After the grain-size distribution analyses the sand samples of the Dévaványa profile were divided into fractions, then the minerals of the fraction of 0.1—0.2 mm were separated into groups of minerals of lighter and heavier than 2.8 by means of the traditional bromoform method.

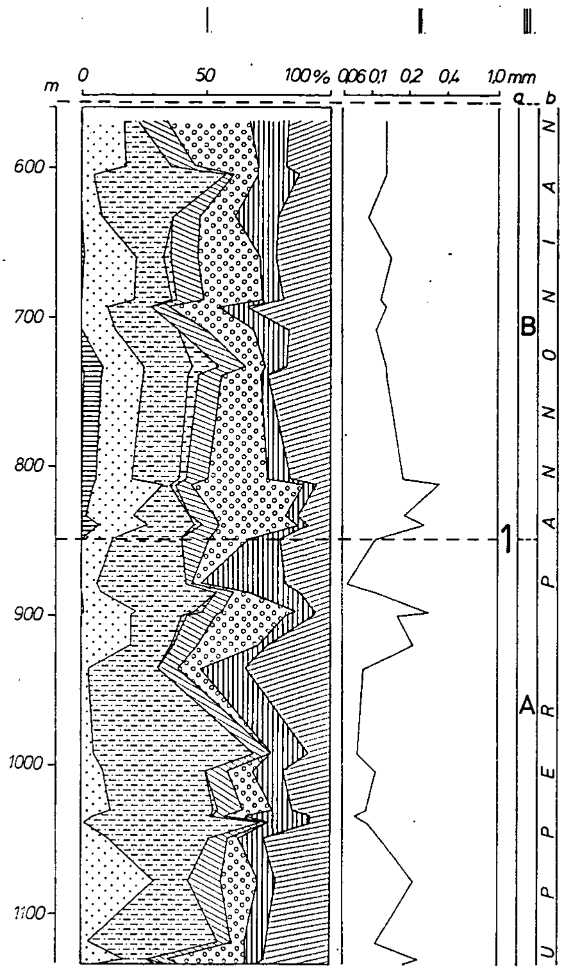

Fig. 2. Heavy mineral and grain-size distribution results of the section between 430 and 1135 m in the Dévaványa profile (Legend: see in *Fig. 3*).

The most important investigations results concerning the Dévaványa profile were demonstrated in a comprehensive profile *(Figs. 2—3)*. When grouping the results according to the geological age the following statements can be mentioned.

RESULTS CONCERNING THE UPPER PANNONIAN FORMATIONS

The Upper Pannonian was discovered by the borehole between 420 and 1137.5 m, i. e. in a length of 713.5 m. According to Franyó [1977] and to our grain-size distribution analyses, in this sequence of Dévaványa the sandy strate are frequent, this it is rather suitable to heavy mineral analyses. 42 samples were analyzed from this section of the profile. The predominating grain-size of the analyzed sand strata is between 0,065 and 0.36 mm, i. e. within a rather wide range.

On the basis of the heavy mineral composition three greater sections can be distinguished in the sequence *(Fig. 2)*.

Section 1

1/A. In the section between 847.57 and 1135.31 m i. e. of 287.0 m thickness the micromineralogical analysis of 17 sand strata was carried out. The grain size varies between 0.065 and 0.28 mm. The heavy mineral composition is characterized by simplicity, only a few mineral species occur. Regarding the quantities, the most important mineral is the chlorite showing 9 to 44 percent. Garnet and magnetite-ilmenite are also important but their quantities strongly fluctuate *(Fig. 2.)*.

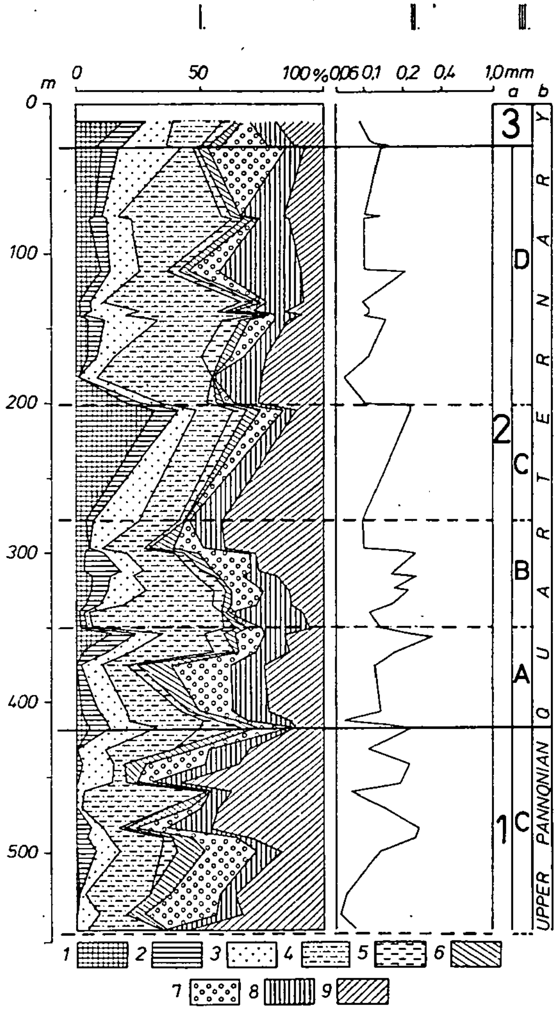

Fig. 3. Heavy mineral and grain-size distribution results of the section between 0 and 551 m in the Dévaványa profile.
Legend: *1* = hypersthene and augite; *2* = basaltic amphibole; *3* = magnetite-ilmenite; *4* = biotite and chlorite; *5* = hornblende; *6* = tourmaline; epidote, clinozoisite, rutile and actinolite-tremolite; *7* = garnet; *8* = other minerals, total; *9* = weathered minerals.

It is worthy of mention that rutile is represented by relatively high, i. e. 0.4 to 6.4% values and the otherwise rarely occurring glaucophane; the latter occurred in the two deepest strata.

The pictures 1 and 2 of Plate I show the occurrence of the minerals in the sequence introduced above. In the pictures small number of mineral species is found. In photo No. 1. chlorite, garnet and weathered mineral predominate. In Photo No. 2 the carbonatic rock detritus can be seen deriving from 878—879 m. Within the whole profile this sample showed the highest carbonate mineral content, i. e. 23.4%.

1/B. 14 strata were analyzed from the 270 m long section between 568.34 and 839.00 m from the micromineralogical point of view. The predominating grain size of the samples varies between 0.095 and 0.36 mm. Omitting, however, the smallest value, this figure lies between 0.11 and 0.36 mm. Consequently, samples consist of the fine- and medium-grained sand being most suitable for heavy mineral analyses [MOLNÁR, B., 1970b].

When looking at *Fig. 2* the difference from the under- and overlying strata can be fairly well seen. The sequence is here more varied and more mineral species occur. In addition to the metamorphic minerals the igneous minerals become also important due to the higher frequency of the basaltic amphibole of igneous origin. As compared to the section 1/A magnetite is of greater importance and its quantities amount from 5 to 21.4%. Chlorite, however, is somewhat decreased but its quantity shows greater fluctuations between 2.8 and 52.5%. Rutile is also slightly decreased but belongs to the minerals the significance of which is increased. The assemblage consisting of tourmaline, epidote, clinozoisite, rutile and actinolite-tremolite shows somewhat higher percentages (*Fig. 2,* I/5). The weathered minerals show more equilibrated values.

In photos No. 3 and 4 of Plate I the changes mentioned above can be fairly well observed. Several new minerals occur, e. g. the basaltic amphibole, the hornblende, the actinolite-tremolite, or the tourmaline. Of course, in the photo the minerals known from the previous sections also occur, e. g. garnet, chlorite and the weathered mineral.

1/C. Eleven strata were analyzed from the section of 121 m between 430.33 and 551.77 m. As it has been mentioned in the introduction, the lower lacustrine facies of the sequence below 490 m contains first of all fine sand, while upward, to the fluviatile facies, mainly coarser, fine- and medium-grained sand. The lowest and highest values of the predominating grain-size are 0.065 and 0.26 mm, respectively *(Fig. 3,* II*)*.

As compared to the underlying sequence the following changes can be observed in the heavy mineral composition. The percentage of magnetite-ilmenite decreases. In some strata apatite becomes unusually abundant, e. g. in the depth between 470.57 and 470.90 m it amounts to 5.8%. Biotite and chlorite play more and less significant role, respectively, the value of both of them changes rapidly. Titanite which occurred in the former samples not always but rather frequently, is practically absent here.

Garnet is abundant in the lower parts and topwards decreases gradually except one layer (440—441 m). Siderite occurs in this section first between 497 and 498 m.

The amount of weathered, incrusted minerals which cannot be determined by means of optical methods, suddenly increases. The differences in weathering caused by climatic effects may be responsible for this phenomenon. This sequence was deposited at the boundary of the warmer Pliocene and cooler Quaternary at which moment the climate change had decisive impact on many geological processes. The total absence of carbonate minerals is worthy of note which can be related also to the increased intensity of weathering of the changed character of weathering itself.

It can be seen, however, that during facies change, i. e. between the lacustrine and fluviatile formations no change in mineral composition followed.

Photos 1 and 2 of Plate II shows fairly well most of the differences mentioned above. More weathered minerals occur. In photo No. 1 well-developed biotites can be seen.

INVESTIGATION RESULTS OF THE QUATERNARY FORMATIONS

In the Quaternary formations the change in heavy mineral composition is more rapid than observed before. Thus, one sedimentary cycle is of smaller thickness. In the Great Plain the fluviatile sedimentation becomes common after the Pliocene; in the environs of Dévaványa the sediment formation of four rivers may alternate in space and time on the alluvial fan of the River Körös. Thus, this rapid change seems to be possible.

Within the Quaternary formations two fairly well distinguishable sections can be identified on the basis of the changes in heavy mineral composition. Out of the two greater phases, the *lower* represents the Pleistocene and can be divided into four smaller sub-units. As to our opinion, the *upper* section can be identified with the Holocene formation. Each sedimentary sections can be characterized as follows.

Section 2

2/A. Eight samples were analyzed from 64 m thick sequence between 352.67 and 416.80 m *(Fig. 3)*. In *Fig.* 3 the heavy mineral compositions are demonstrated comprehensively or in average due to dense sampling and in favour of better demonstration.

The predominating grain-size of the studied strata varies between 0.07 and 0.32 mm. In this depth interval, however, only fine- and medium-grained sands occur except the only fine-grained sand layer.

As compared to the underlying Pliocene sequence considerable change follows in the heavy mineral composition. Between 416.70 and 430.33 m a sharp boundary can be delineated which could be drawn so far, neither. Upward from this depth mineral composition is much more varied and much more species of minerals occur. The proportion of igneous minerals is increased. Hypersthene, augite, basaltic amphibole as well as the hornblende become much more important. This change does not suddenly follow. First, the igneous and metamorphic characters alternate, then the metamorphic character disappears. The minerals occurring in these sediments are also significant ingredients of the alluvium of the rivers flowing to the Great Plain from the east [MOLNÁR, B., 1964*a*, *b*]. The sediments were, thus, deposited by these rivers or by their ancestors.

Taking into account the occurrence and changes of the mineral species the following can be stated. Hypersthene was practically absent so far. Neverheless, between 354 and 356 m its quantity exceeds 10%, though its amount shows fluctuations, e. g. between 374 and 375 m it is absent. The same can be said in case of augite. The basaltic amphibole, however, shows nearly the same quantities, i. e. between 5 and 10%, except one case. Chlorite is much as compared to the recent alluvia of the rivers getting the Great Plain from the east. Rutile was found in all strata. The hornblende shows more uniform values than in the preceding section of 1/C. The quantity of garnet is somewhat greater, while that of the weathered mineral is somewhat less. Siderite occurs with relatively high percentages between 365 and 366 m.

The changes shown above are demonstrated in the photos No. 3 and 4 of Plate II. Minerals unusual till now occur, e. g. hypersthene, or augite, and the basaltic amphibole is also more frequent.

2/B. Twelve samples were analyzed in the 72 m thick section between 278.15 and 350.98 m. The grain-size distribution of the sand samples is uniform. Nearly all the strata are fine-grained or similar grain-size sands.

It is characteristic of the heavy mineral composition of the sequence that somewhat less mineral species are found than in the section 2/C. First of all, the metamorphic minerals are lacking. E. g. the quantities of tourmaline, epidote, clinozoisite and kyanite decrease. Hypersthene is found though in smaller amounts than in the preceding section. The quantity of chlorite increases again. The upward increasing quantity of the weathering mineral is worthy of mention.

Minerals deriving from this section can be seen in Plate III. The corroded augites and hypersthenes are frequent. In photo No. 3 spherical siderites can be seen.

2/C. Three strata were analyzed from the 5 m thick fine- and medium-grained sand between 200.35 and 205.70 m. Between the end of section 2/A and the beginning of section 2/C, i. e. between 205.70 and 278.15 m only strata finer than sands are deposited in a thickness of 75 m, so in this part no heavy mineral investigations could be carried out.

Being in possession of the regularities of cyclic built-up of the fluviatile sedimentary sequences of the Great Plain, it can be stated that subsequently to this fine-grained section a new fluviatile accumulation cycle is started at section 2/C which can be traced back to tectonic reasons [Miháltz, I., 1955; Molnár, B., 1967, 1968, 1970*a*, *b*, 1973, 1975].

This change is also reflected by the change of the heavy mineral composition. Hypersthene and augite show considerable percentages though with rather fluctuating values *(Fig. 3)*. Grain-size becomes coarser upwards and this is not accompanied by the expected accumulation of garnet, thus this phenomenon reflects difference in the source area. The quantity of chlorite is higher only in the uppermost fine-grained sand sample. When comparing this composition with that of the recent rivers reaching the Great Plain form the east, it can be stated that this sediment was deposited by the rivers Fekete and Fehér Körös [Molnár, B., 1964*a*, *b*].

2/D. The results obtained from twelve samples in the 110 m thick section between 74.56 and 185.12 m showed that this section is the repetition of the sequence of 2/B between 278.15 and 350.98 m, in many respects. The difference is caused first of all by the greater amounts of biotite and smaller quantities of weathered minerals. The three significant igneous minerals, i. e. hypersthene, augite and basaltic amphibole shows here also similar fluctuating values. The metamorphic minerals are even less important, this is reflected e. g. by the smaller percentages of tourmaline.

The photos in Plate IV. illustrate the facts listed above. In photo No.1 characteristic biotites are seen. Photo No. 2 shows the heavy minerals of the stratum between 112.0 and 112.6 m. In the picture several hypersthene, augite and mainly basaltic amphibole can be seen. Photo No. 3 proves the increased quantity of chlorite. In photo No. 4 the mineral assemblage is more varied again.

Section 3

The heavy mineral analysis of 5 strata was carried out in the 17 m thick section between 12.10 and 29.41 m. Except the uppermost layer, all the strata show the predominating grain-size within the fine-grained sand, in rather uniform distribution, i. e. between 0.11 and 0.15 mm, without considerable fluctuations. The uppermost layer proved to be fine-grained sand.

The heavy mineral composition is characterized by uniform distribution. Hypersthene, augite and the basaltic amphibole play important role. Magnetite-ilmenite shows nearly the same quantity in all samples. As compared to section 2/C it is significant change that biotite and chlorite shows smaller while garnet greater quantities. When comparing this sequence with the alluvia of recent rivers it can be stated that it was deposited by the river Hármas-Körös. The heavy mineral composition is the same as in the alluvium of the Hármas-Körös [MOLNÁR, B., 1964*a*, *b*].

Photos in Plate V. show this variegated mineral assemblage showing small quantities of chlorite. Within the whole section the mechanical weathering and rounding of minerals can be observed only in one layer, between 25.45 and 26.16 m (Plate V, 2). In other sections chemical weathering effects, mainly corrosion are characteristic of the minerals.

The sediments of section 3 were deposited during the Holocene. The Pleistocene-Holocene boundary lies somewhere between 29.41 and 74.56 m, but rather closer to the shallow depths. The beginning of the recent Hármas-Körös sedimentation means a new accumulation cycle and this is accompanied by Holocene cutting and subsequent filling everywhere in the southern part of the Great Plain, e. g. in case of the river Tisza [MIHÁLTZ, I., 1967].

CONCLUSIONS

On the basis of the micromineralcgical analyses of the Dévaványa profile the following can be stated:

1. The heavy mineral composition of the upper part of Upper Pannonian and of the Quaternary formations differs from each other. The quantity of metamorphic minerals decreases downwards. In the Quaternary sequence hpyersthene, augite and basaltic amphibole play more important role than in the underlying strata.

2. The change in the heavy mineral composition, i. e. the change of source area is less frequent in the Upper part of Upper Pannonian, and more frequent in the Quaternary. The thickness of the sedimentary section of the same composition amounts to 120—270 m in the Upper Pannonian and only to 5—110 m in the Quaternary.

3. On the basis of the heavy minerals composition the repetition of sequences can be observed in the Quaternary strata, this is provided by the fluviatile facies deposited beside and above each other in space and time.

4. The most important change in the heavy mineral composition can be identified in 416.0 m. Above this boundary, i. e. in the Quaternary formations the sediments of the recent rivers or their ancestors can be found. This is proved first of all by the presence of three characteristic igneous minerals, i. e. hypersthene, augite and basaltic amphibole.

5. The alluvium of the recent Hármas-Körös can be identified upwards from 29.41 m.

6. The boundary determined in a depth of 416.0 m at Dévaványa corresponds fairly well to the thickness map contoured earlier for the sediments of the River Tisza and its tributaries. Starting from the Tisza-line the lower boundary of the sediments deposited by the recent Tisza and its tributaries becomes ever greater depths. In Berettyóújfalu-Békés profile lying east of Dévaványa this boundary is found in a depth of about 500 m.

7. The northern tributaries of the Tisza, the alluvia of which contains first of all hypersthene and augite and less basaltic amphibole, never reached the line of the Hármas Körös [Molnár, B., 1965, 1966*a*, *b*, 1968, 1970*a*, *b*].

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EXPLANATION OF PLATES

PLATE I

Heavy minerals of sand samples of the Upper Pannonian of the Dévaványa profile (Section 1; A: Photos 1—2; B: Photos 3—4).

Photos were made by transmitted light microscope, with parallel nicols, minerals were imbedded in nitrobenzene of 1.552 refraction. In all pictures the heavy minerals of the fraction 0.1—0.2 mm are seen. — Abbreviations: *H*=hypersthene; *Au*=augite; *Di*=diopside; *BH*=Basaltic amphibole; *M*=magnetite-ilmenite; *B*=biotite; *Ch*=chlorite; *T*=tourmaline; *E*=epidote; *Cz*=clinozoisite; *Ho*=hornblende; *Ac—Tr*=actinolite-tremolite; *G*=garnet; *K*=kyanite; *C*=calcite-dolomite, or carbonatic detritus; *S*=siderite; *Wm*=weathered minerals.

1. 1132.67—1135.31 m
2. 878.91— 879.43 m
3. 838.27— 839.00 m
4. 732.64— 733.56 m

PLATE II

Heavy minerals of the Upper Pannonian and Pleistocene samples of the Dévaványa profile (Section 1C: Photos 1—2; Section 2A: Photos 3—4).

1. 459.02—459.80 m
2. 440.60—441.18 m
3. 415.87—416.42 m
4. 352.67—358.85 m

PLATE III

Heavy minerals of Pleistocene sand samples of the Dévaványa profile (Section 2B: Photos 1—4)

1. 325.45—325.90 m
2. 315.84—316.50 m
3. 324.25—315.34 m
4. 298.30—298.92 m

PLATE IV

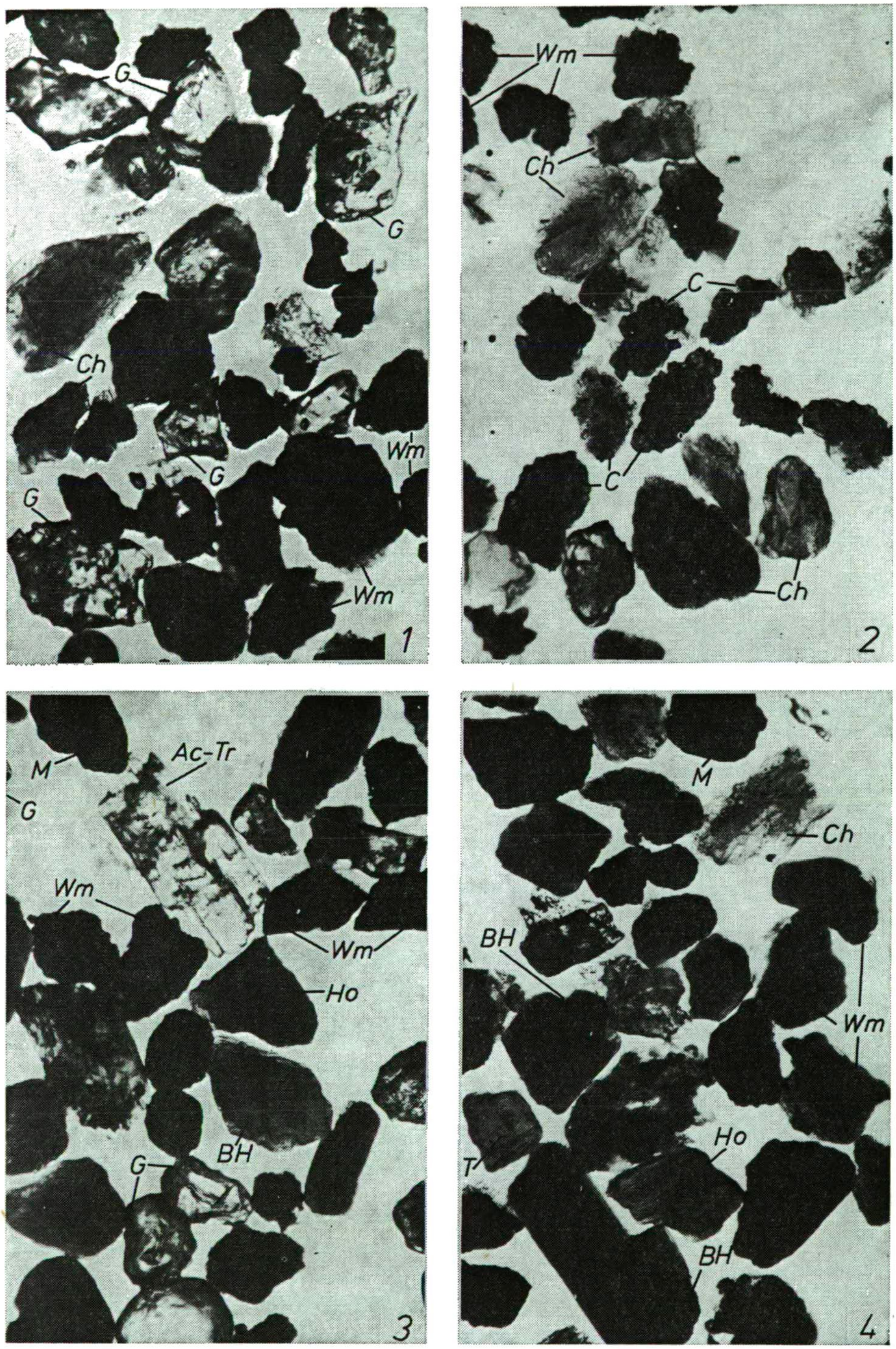
Heavy minerals of Pleistocene sand samples of the Dévaványa profile (Section 2D: Photos 1—4)

1. 168.55—169.66 m
2. 112.00—112.16 m
3. 111.76—111.85 m
4. 76.64— 77.00 m

PLATE V

Heavy minerals of Holocene sand samples of the Dévaványa profile (Section 3: Photos 1—4)

1. 29.15—29.24 m
2. 25.45—26.16 m
3. 12.10—12.41/a m
4. 12.10—12.41/b m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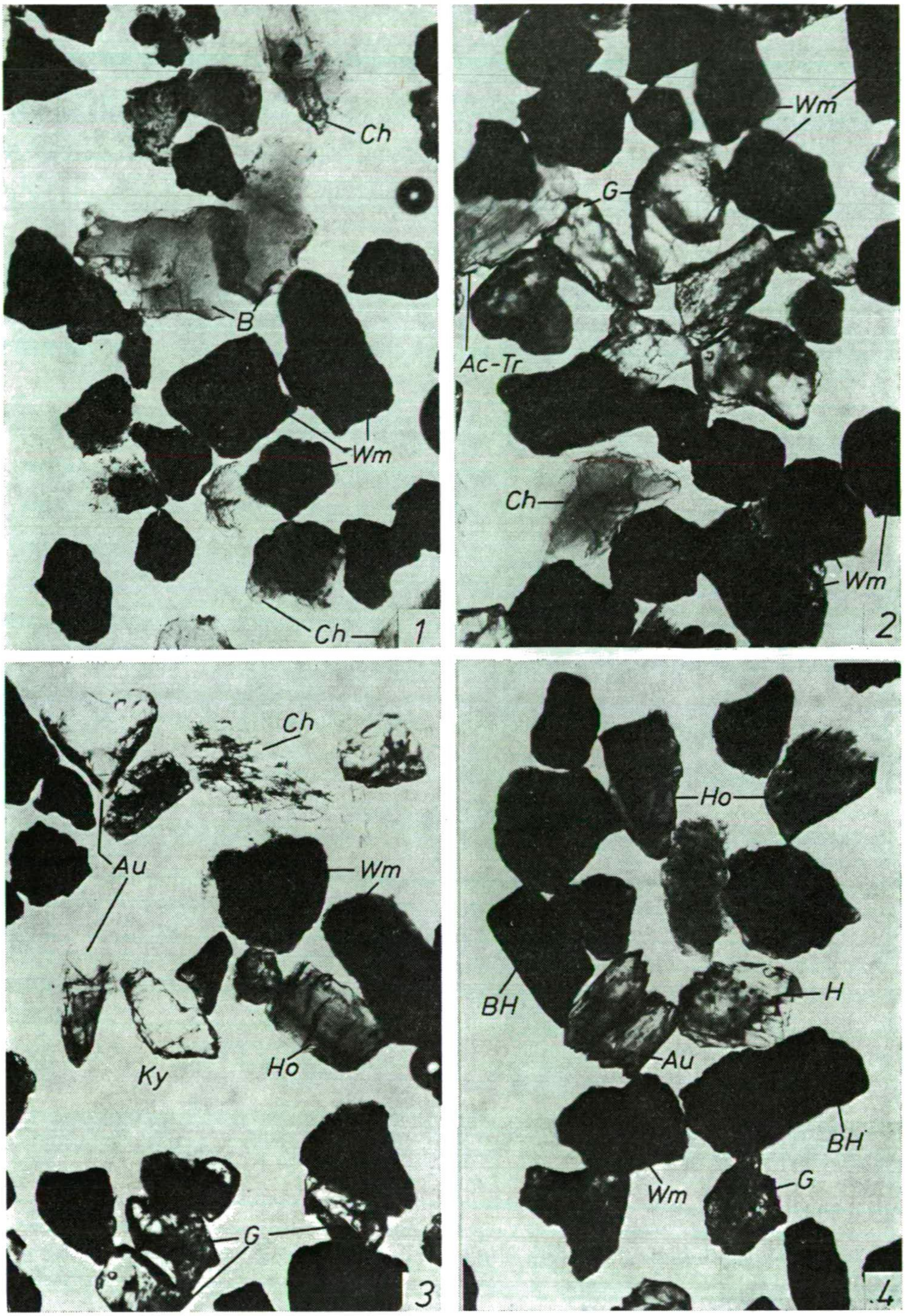
BH
4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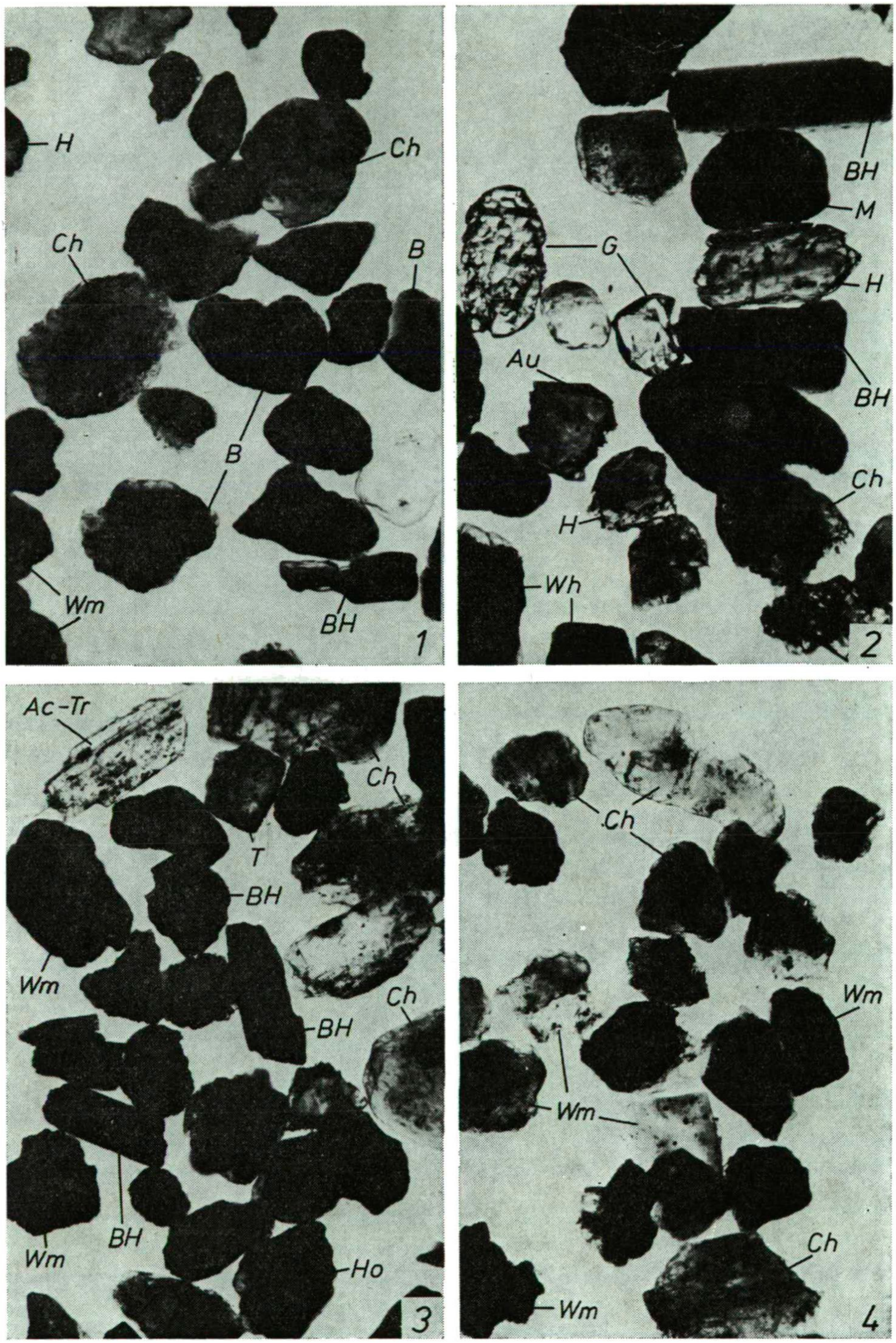
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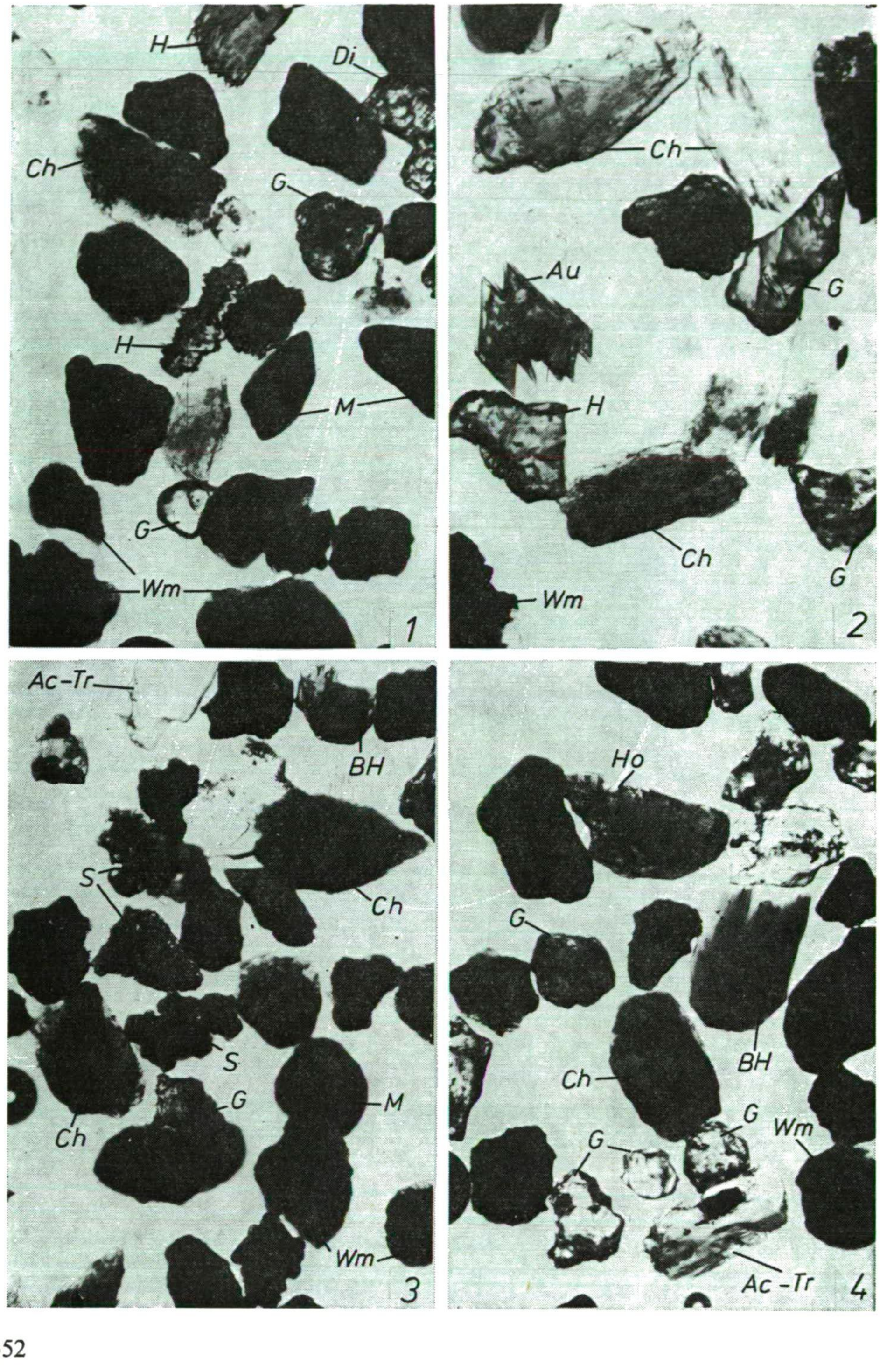
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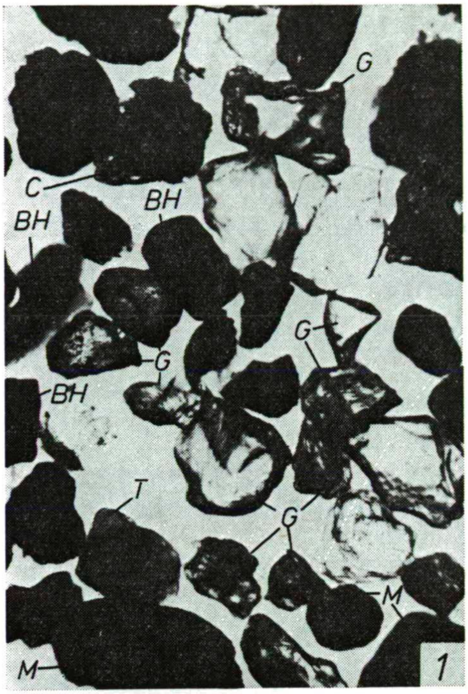
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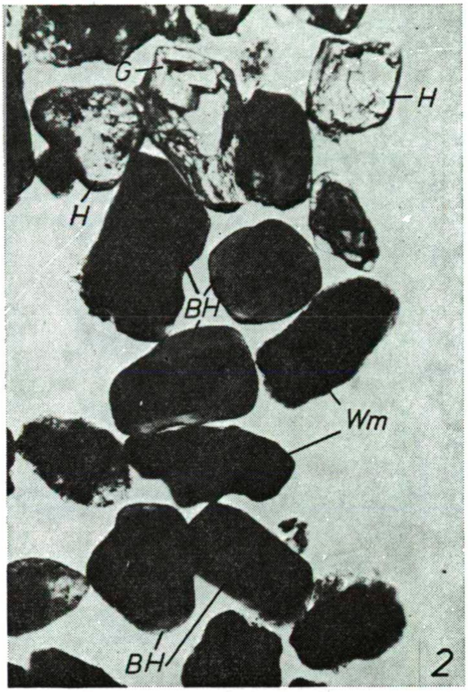
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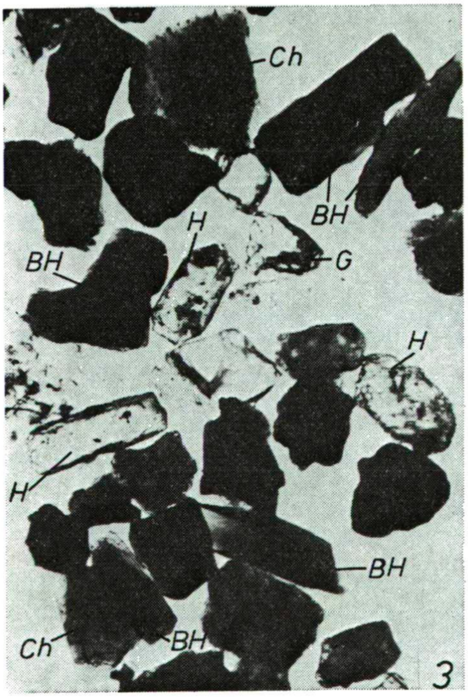
2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H
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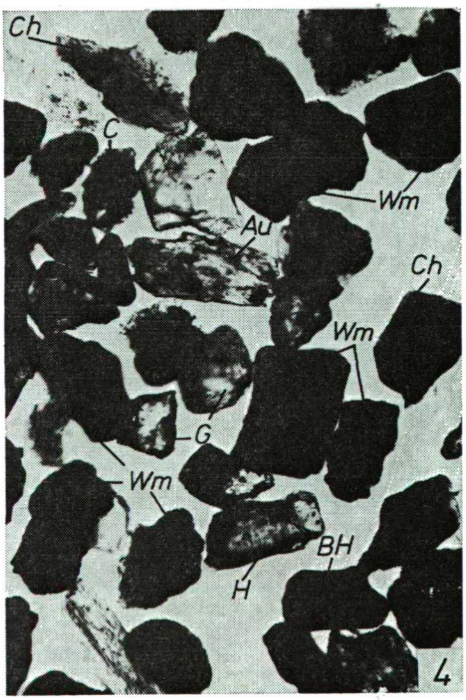
Ch
C
Wm
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Ch
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H
4